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Planning and Design of Rigid Pavement

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ABSTRACT

Transportation is one of the main contributions in the development of economic, social, industrial and cultural aspects of any country. The main aim of transportation is to transport goods, services and passengers from one place to the other. The cost of any commodity is greatly dependent on the transportation. Also the development of rural areas can be achieved by the improvement of transportation facilities to them. The purpose of a rigid pavement design is to determine the thickness of the layers and the quality of the materials used in the pavement. The stresses occurring in a pavement should not exceed the modulus of rupture of the concrete. In this study, the answer to the most reliable and cost-effective solution for a pavement design for a single axle and different temperature gradient was investigated. Our project is located at Gudur Mandal, S.P.S.R Nellore District, which is under classification of State Highway SH-58 from Gudur to Rapur via Sydapuram and A part from that we have taken a stretch of 1km.The starting chainage of Gudur is 0km and ending chainage is 37km. Hence we started at 2.9km chainage up to 3.9km chainage. The aim of the project is to design a rigid pavement by conducting suitable surveys, soil investigations, calculation of earth work quantities, geometric design and desirable cross drainage works.

Keywords:-

I. INTRODUCTION

Mobility is a basic human need. From the times immemorial, everyone travels either for food or leisure. A closely associated need is the transport of raw materials to a manufacturing unit or finished goods for consumption. Transportation fulfils these basic needs of humanity. Transportation plays a major role in the development of the human civilization. For instance, one could easily observe the strong correlation between the evolution of human settlement and the proximity of transport facilities. Also, there is a strong correlation between the quality of transport facilities and standard of living, because of which society places a great expectation from transportation facilities. In other words, the solution to transportation problems must be analytically based, economically sound, socially credible, environmentally sensitive, practically acceptable and sustainable. Alternatively, the transportation solution should be safe, rapid, comfortable, convenient, economical, and eco-friendly for both men and material.

Transportation system

In the last couple of decades transportation systems analysis has emerged as a recognized profession. More and more government organizations, universities, researchers, consultants, and private industrial groups around the world are becoming truly multi-modal in their orientation and are opting a systematic approach to transportation problems.

Pavement analysis and design:

Pavement design deals with the structural design of roads, both (bituminous and concrete), commonly known as (flexible pavements and rigid pavements) respectively. It deals with the design of paving materials, determination of the layer thickness, and construction and maintenance procedures. The design mainly covers structural aspects, functional aspects, drainage. Structural design ensures the pavement has enough strength to withstand the impact of loads, functional design emphasizes on the riding quality, and the drainage design protects the pavement from damage due to water infiltration.

Significance of transport:

Transport plays a significant role in the overall economic development. Transportation results into growth of infrastructure, industrialization and massive production. Advancement in the transport sector has resulted into comfort and convenience. Well-functioning transportation systems

form the basis for economic prosperity and social well being of societies

1.1 History of highway engineering

The history of highway engineering gives us an idea about the roads of ancient times. Roads in Rome were constructed in a large scale and it radiated in many directions helping them in military operations. Thus they are considered to be pioneers in road construction. In this section we will see in detail about Ancient roads, Roman roads, British roads, French roads etc.

1.2. Highway planning in India:

Excavations in the sites of Indus valley, Mohenjo-dero and Harappan civilizations revealed the existence of planned roads in India as old as 2500-3500 BC. The Mauryan kings also built very good roads. Ancient books like Arthashastra written by Kautilya, a great administrator of the Mauryan times, contained rules for regulating traffic, depths of roads for various purposes, and punishments for obstructing traffic. During the time of Mughal period, roads in India were greatly improved. Roads linking North-West and the Eastern areas through gangetic plains were built during this time. After the fall of the Mughals and at the beginning of British rule, many existing roads were improved. The construction of Grand-Trunk road connecting North and South is a major contribution of the British. However, the focus was later shifted to railways, except for feeder roads to important stations.

II. SOIL SAMPLING

Soil investigation has been carried out to determine the properties of soil present in the area of proposed road. As per the Indian standard specifications for the collection of soil samples, a site is selected and a pit of size 1m x 1m x 1m is dug .As the soil is varying along the length of the proposed road, one pit is dug and soil samples are collected for soil tests.

Various tests conducted on the soil samples in the laboratory to determine the index properties and engineering properties are as follows:

1. Specific gravity
2. Sieve analysis
3. Liquid limit
4. Plastic limit
5. Shrinkage limit
6. Standard proctor test
7. California bearing ratio test

2.1. TEST REPORTS

Various properties of the soil are reported as below:

S.NO	PROPERTY	VALUES
1	Liquid Limit	36.2%
2	Plastic Limit	18.03%
3	Shrinkage Limit	26.82%
4	Effective Size (D_{10})	0.16
5	Uniformity Coefficient (C_u)	3.75
6	Coefficient Of Curvature (c_c)	2.109
7	Soil Group	SC
8	Optimum Moisture Content (omc)	10%
9	Maximum Dry Density Of The Soil (Y_d) **max**	26.627 kn/m^3
10	CBR Value Of Soil In Soaked Condition	4%

FIG 1: Liquid limit

Fig2 : CBR

III. ENGINEERING SURVEYS

The following are the engineering surveys to be carried out before finalizing highway Alignment.

1. Map study
2. Reconnaissance Survey

3. Preliminary survey

4. Traffic Survey

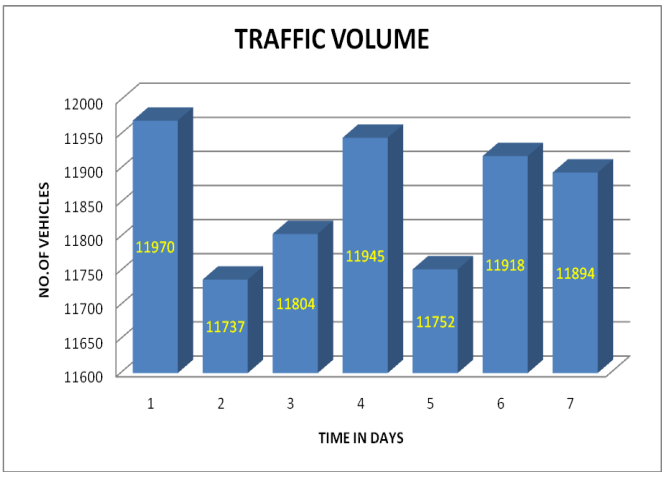
3.1. TRAFFIC VOLUME SURVEY REPORT:

Traffic volume survey report from 09-02-2018 to 15-02-2018
Duration period of Traffic survey = 7 days

Calculation of commercial vehicles (Laden weight >3tonnes):

DATE	TOTAL VEHICLES	NO.OF COMMERCIAL VEHICLES
09-02-2018	11970	362
10-02-2018	11737	395
11-02-2018	11804	422
12-02-2018	11945	451
13-02-2018	11752	420
14-02-2018	11918	381
15-02-2018	11894	400

Average number of commercial vehicles=404



3.3. EARTH WORK QUANTITIES:

A Highway construction usually involves earthwork either in cutting or filling calculated based on levelling and drawings. In this project a detailed levelling was carried out and longitudinal section and cross section were drawn.

EARTH WORK CALCULATIONS:

The volume is calculated by using trapezoidal formula
V=H*{((
$A_0 + A_n)/2) + (A_1 + A_2 + A_3 + \ldots\ldots A_{n-1})\}$

Where $A_1, A_2, A_3 \ldots\ldots A_n$ are the areas at corresponding points,
H= Class interval

Quantity of Banking = **2112.875 m³**

Quantity of cutting = **513.675 m³**

Volume of earth required for banking =2112.875-513.675

=1599.2 **m³**

IV. INTRODUCTION TO GEOMETRIC DESIGN

The geometric design of highways deals with the dimensions and layout of visible features of the highway. theemphasis of the geometric design is to address the requirement of the driver and the vehicle such assafety, comfort, efficiency, etc. The features normally considered are the cross section elements, sight distanceconsideration, horizontal curvature, gradients, and intersection. The design of these features is to a greatextend influenced by driver behavior and psychology, vehicle characteristics, traffic characteristics such as speedand volume. Proper geometric design will help in the reduction of accidents and their severity. Therefore,the objective of geometric design is to provide optimum efficiency in traffic operation and maximum safety atreasonable cost.

Cross sectional elements:

1 Overview:

The features of the cross-section of the pavement influences the life of the pavement as well as the riding comfort and safety. Of these, pavement surface characteristics affect both of these. Camber,kerbs, and geometry of various cross-sectional elements are important aspects to be considered in this regard. They are explained briefly in this chapter.

2 Pavement surface characteristics:

For a safe and comfortable driving four aspects of the pavement surface are important; the friction between the wheels and the pavement surface, smoothness of the road surface, the light reflection characteristics of the top of pavement surface, and drainage to water.

2.1Friction:

Skidding happens when the path traveled along the road surface is more than the circumferential movement of the wheels due to friction .

Slip occurs when the wheel revolves more than the corresponding longitudinal movement alongtheroad.

2.2.Unevenness:

It is always desirable to have an even surface, but it is seldom possible to have such one. Even if a road is constructed with high quality pavers, it is possible to develop unevenness due to pavement failures. Unevenness affect the vehicle operating cost, speed, riding comfort, safety, fuel consumption and wear and tear of tyres.

2.3 Light reflection:

White roads have good visibility at night, but caused glare during day time.

Black roads has no glare during day, but has poor visibility at night

Concrete roads has better visibility and less glare

It is necessary that the road surface should be visible at night and reflection of light is the factor that answers it.

2.4 Drainage

The pavement surface should be absolutely impermeable to prevent seepage of water into the pavement layers. Further,both the geometry and texture of pavement surface should help in draining out the water from the surface in less time.

3 Camber:

Camber or cant is the cross slope provided to raise middle of the road surface in the transverse direction to drain o rain water from road surface. The objectives of providing camber are:

1. Surface protection especially for gravel and bituminous roads
2. Sub-grade protection by proper drainage
3. Quick drying of pavement which in turn increases safety

4 Width of carriage way:

Width of the carriage way or the width of the pavement depends on the width of the traffic lane and number of lanes. Width of a traffic lane depends on the width of the vehicle and the clearance. Side clearance improves operating speed and safety. The maximum permissible width of a vehicle is 2.44 and the desirable side clearance for single lane traffic is 0.68 m. This require minimum of lane width of 3.75 m for a single lane road.

5. Kerbs:

Kerbs indicate the boundary between the carriage way and the shoulder or islands or footpaths.

6. Road margins:

The portion of the road beyond the carriageway and on the roadway can be generally called road margin.

6.1 Shoulders:

Shoulders are provided along the road edge and is intended for accommodation of stopped vehicles, serve as an emergency lane for vehicles and provide lateral support for base and surface courses. The shoulder should be strong enough to bear the weight of a fully loaded truck even in wet conditions. The shoulder width should be adequate for giving working space around a stopped vehicle. It is desirable to have a width of 4.6 m for the shoulders. A minimum width of 2.5 m is recommended for 2-lane rural highways in India.

6.2 Parking lanes:

Parking lanes are provided in urban lanes for side parking. Parallel parking is preferred because it is safe for the vehicles moving in the road. The parking lane should have a minimum of 3.0 m width in the case of parallel parking.

6.3 Bus-bays:

Bus bays are provided by recessing the kerbs for bus stops. They are provided so that they do not obstruct the movement of vehicles in the carriage way. They should be at least 75 meters away from the intersection so that the traffic near the intersections is not affected by the bus-bay.

6.4 Service roads

Service roads or frontage roads give access to access controlled highways like freeways and expressways. They run parallel to the highway and will be usually isolated by a separator and access to the highway will be provided only at selected points. These roads are provided to avoid congestion in the expressways and also the speed of the traffic in those lanes is not reduced.

6.5 Cycle track

Cycle tracks are provided in urban areas when the volume of cycle traffic is high Minimum width of 2 meter is required, which may be increased by 1 meter for every additional track.

6.6 Footpath

Footpaths are exclusive right of way to pedestrians, especially in urban areas. They are provided for the safety of the pedestrians when both the pedestrian traffic and vehicular traffic is high. Minimum width is 1.5 meter and may be increased based on the traffic. The footpath should be either as smooth as the pavement or more smoother than that to induce the pedestrian to use the footpath.

6.7 Guard rails

They are provided at the edge of the shoulder usually when the road is on an embankment. They serve to prevent the vehicles from running o the embankment, especially when the height of the fill exceeds 3 m. Various designs of guard rails are there. Guard stones painted in alternate black and white are usually used. They also give better visibility of curves at night under headlights of vehicles.

5.2Width of formation

Width of formation or roadway width is the sum of the widths of pavements or carriage way including separators and shoulders. This does not include the extra land in formation/cutting. The values suggested by IRC are given in Table 3.

Table 3: Width of formation for various classed of roads

Road classification	Roadway width in m	
	Plain and rolling terrain	Mountainous and steep terrain
NH/SH	12	6.25-8.8
MDR	9	4.75
ODR	7.5-9.0	4.75
VR	7.5	4.0

V. MATERIAL SPECIFICATIONS

5.1. AGGREGATE SPECIFICATIONS

1 .Aggregate crushing value is=21.06% (as shown i fig 5)

Fig 5 Fig 6

2.Aggregate Impact Value is=21.48% (as shown in fig 6)

Fig 7 Fig 8

3 . Aggregate Abrasion Value is=23.14% (as shown in fig7)

4 .Water Absorption value is =0.6% (as shown in fig 8)

5 . Specific Gravity of Aggregate is =2.53 (as shown in fig 9)

6 . Elongation Index Value is=19.94% (as shown in fig 10)

Fig 9

Fig 10

5.2. SPECIFICATIONS OF CEMENT:

1.Fineness of cement =5% (as shown in fig 11)

2 .Specific gravity of cement =**3.15** (as shown in fig 12)

Fig 11

Fig12

5.3. SPECIFICATIONS OF FLY ASH:

1.Specific Gravity of FlyAsh=2.2 (as shown in fig 11)

2.Fineness Of Fly Ash =5% (as shown in Fig 12)

Fig 11

Fig 12

VI. DESIGN OF PAVEMENT

Design of rigid pavement can be done by the following ways:

1. Group index method
2. California bearing ratio method
3. Triaxial method
4. Burmister method

Among the above methods, we used CBR method to design the pavement. In order to design a pavement by CBR method, first soaked CBR value of the soil sub grade is evaluated. Then the appropriate design curve is chosen by taking the design wheel load or by taking the anticipated traffic into considerations.

Various aspects of design of pavement

1. Strength
2. Durability
3. Appearance
4. Riding quality

6.1. DESIGN OF SLAB THICKNESS

Slab Thicknes s (cm)	**Maxi mum Contr action Joint spacin g (m)**	**Weight of reinforcement In welded fabric (for Reinforced pavements only) (kg . sq m)**
Un reinforced slab 10 15 20	 4.5 4.5 4.5	 _ _ _
Reinforce d slabs 10 15 20	 7.5 13.0 14.0	 2.2 2.7 3.8

6.2. DESIGN OF SUB BASE AND BASE LAYERS:

Based on the specifications of IRC, for 7kg/cm^2 and CBR 4%

Sub base layer of compacted thickness is taken as 150mm as GSB.

Base layer thickness is provided as 100mm and prepared with PCC of 1:4:8 M7.

6.3. LABORATORY TESTS FOR SLAB DESIGN:

COMPRESSIVE STRENGTH OF CEMENT CONCRETE CUBES (M30).

Compressive strength of 10% &15% fly ash mixed concrete

• No.of days	• 10%flyash	• 15%flyash
• 7	• 29.037	• 28.148
• 14	• 35.1	• 29.19
• 28	• 36.014	• 32

10% fly ash mixed concrete (M_{30}) is suitable for slab design than 15% fly ash mix ,because it reaches the target mean strength at 28 days = 38 N/mm²

VII. HIGHWAY DRAINAGE

The highway engineer should ensure that the precipitation is removed from the pavement as soon as possible and that highway drainage is done efficiently. Water that falls on the road way follows laterally (or) obliquely from it, under influence of cross slope. Or super elevation in pavement and shoulder. A suitable value of cross fall for paved roads is about 3% for carriage way with a slope of 4-6% for shoulders. And increased cross fall for the carriage way e.g.4% is desirable if the quantity of the final shape of the road surface is likely to be low for any reason.

The top of the sub base should have a cross fall of 3-4% and top of the sub grade should be 4-5% .

For the proposed road, the camber is provided as 2%. The slope is within the limit. So itself it can be posses the drainage. Therefore there is no requirement of additional drainage system.

1m of shoulders are provided each side of the road(along with the road edge).There is no requirement of kerbs for the proposed

VIII. CONCLUSION

- The proposed road length of 1000m at Gudur (SH-58) .
- Levelling is carried out for 3.5m width on each side of the center line of the road and longitudinal section has been prepared by taking levels at every 30m for 9m formation width. The width of carriage way is 7m and width of shoulders on each side of the road is 1m. The shoulders are provided with the slope of 1 in 50. The road has no curve sections and is designed for a speed 40Kmph.
- Soil investigation is carried out by both disturbed and undisturbed soil samples and conducting various tests on the samples in the laboratory. The average daily commercial vehicular traffic is estimated to be 400 vehicles.
- Based on the CBR value of 4% of the soil is soaked critical condition, the thickness of the pavement is calculated as 50cm. The thickness of pavement is divided into sub base is provided with a compacted thickness of 150mm using GSB, base layer is provided with a compacted thickness of 100mm using 1:4:8 PCC and 25cm thick surface layer with 10% fly ash mixed M30 grade concrete is provided.
- The index map, longitudinal section, cross sections and the site plan of the proposed road and the designs of the pavement layers are enclosed.

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